

Remarks

The Claim Rejections under 35 U.S.C. 112

Claims 1, 3-5, 7, 8, 10-12, 14, 15, 19-21, 26-29, 48, 49, 54, 55, 57, 61, 63-70 are rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirements.

The Examiner has stated three distinct bases of rejections. These are responded to in the following sections, numbered 1-3. In responding to these rejections, applicants refer to paragraphs in their U.S. Patent Application Publication No. 2005/0191234.

1. The recitation in claim 1 of "...and the oxide remaining as substantially the sole residue material in the hydrogen storage device." is said to render the claim indefinite. The Examiner states that applicants' specification fails to support that the oxide is in the form of a residue. Applicants' response is as follows.

A previous portion of independent claim 1 requires that the particles of hydride react substantially completely with the water and particles of hydroxide to form hydrogen and an oxide. As disclosed in each of the many specific equations in the specification, the hydride, and hydroxide (or hydrated hydroxide), and water are consumed. The only reaction products from the hydride/hydroxide particulate mixture are hydrogen and an oxide or oxides. For example, paragraph 0137 illustrates the reaction of lithium borohydride, lithium hydroxide, and hydrated lithium hydroxide to form two oxides and hydrogen gas. The hydrogen gas leaves the solid-state mixture and is delivered to a hydrogen consuming application. The oxides are solids, and, thus only the oxides remain as the residue or byproduct of the original hydride and hydroxide (or hydrated hydroxide) particles. And, as stated in paragraph 0056, the byproduct oxide material will absorb and react with hydrogen to regenerate a species of the original (and consumed) hydride and hydroxide.

Any worker skilled in the art of hydrogen storage materials would recognize from applicants' specification, considered as a whole, that a goal of their hydrogen storage material formulations is to save space and weight by fully using the mixture of starting hydride and

hydroxide particles to produce and deliver hydrogen gas. The only by-product or residue is the oxide or oxides resulting from the initiating reaction of water and a portion of the hydride particles followed by the substantially complete reaction of remaining particles of hydride and particles of hydroxide.

Applicants' specification clearly supports the challenged claim language. It is requested that this rejection be reconsidered and withdrawn.

2. The Examiner states that the recitation of claims 1 and 67 of "preparing a mixture of particles...and placing the prepared mixture in a hydrogen storage device" does not have support in the specification. Applicants' response is as follows.

Paragraphs 0001- 0005 of applicants' specification (including a reference to U.S. patent 6,015,041) describe how hydrogen storage devices have been proposed to facilitate the storage of hydrogen in a solid material composition and, thus, facilitate the use of hydrogen as a source of energy or fuel source, particularly for mobile applications. As clearly stated, the hydrogen storage devices have chambers which house the solid hydrogen storage material. The devices may be constructed for heating of the solid hydrogen storage material to initiate release of hydrogen. And the devices may be constructed for later admitting hydrogen to recharge spent hydrogen storage material. It is desired to increase the available energy content of hydrogen per unit volume and unit mass of storage. And, obviously, in mobile applications such as motor vehicles, the hydrogen storage device, containing the solid hydrogen storage material, must be reasonably accessible by, or near to, the hydrogen-consuming application. With such a background disclosure, applicants in paragraph 0006 state that they provide an improved hydrogen storage composition for use as a hydrogen storage medium, or material in a hydrogen storage device. Paragraph 0039 states that their invention provides a reduction in the overall energy requirements for systems of storage and subsequently releasing hydrogen in mobile units containing fuel cells such as vehicles. And paragraph 0140 repeats the beneficial use of the subject hydrogen storage materials to provide solid phase hydrogen storage for mobile fuel cell applications.

In each of their Examples 1-5, applicants describe the ball milling of examples of their hydrogen storage materials. Mixtures of equal molar ratios of particles of hydrides and hydroxides were prepared by ball milling. Ball milling is a well known method of forming good

mixtures of solid particles, such as mixtures of applicants' hydrides and hydroxides. And paragraph 0104 states that a suitable compressive force may be applied to compact the mixtures of solid particles to increase contact between the mixed particles. Clearly, such mixtures of solid materials are prepared as hydrogen storage materials for placement in a hydrogen storage device.

In these examples, the mixtures of particles were placed in a Sievert's analysis apparatus to assess and illustrate their hydrogen-producing capacity. Since the clear and stated intent of applicants' work was to produce a hydrogen storage material for a hydrogen consuming application, the examples 1-5 used the Sievert's apparatus as a hydrogen storage device. The mixture was then heated in the device to demonstrate the production of hydrogen from the ball milled mixtures.

Paragraphs 0115 and 0117 further refer to the preparation of solid phase starting material mixtures. Clearly the intent of applicants' entire disclosure is to prepare a mixture of hydride and hydroxide particles for delivery of hydrogen. Such hydrogen storage compositions are naturally placed in a suitable hydrogen storage device as described in paragraphs 0001-0006 of their specification and the referenced U.S. Patent 6,015,041.

It is requested that this rejection be reconsidered and withdrawn.

3. The Examiner further states that the recitation in claim 6 of a "hydrogen storage device in proximity to the hydrogen consuming application" does not have support in the specification. Applicants respond as follows.

As summarized in the above sections 1 and 2, applicants' specification repeatedly discloses that their solid-state hydrogen storage material is available for use in mobile hydrogen-consuming applications such as vehicles that are powered by hydrogen-using fuel cells. Obviously, in such mobile applications, the hydrogen storage device or container with its hydrogen storage material must be on the same vehicle as the fuel cell or other hydrogen consuming application. Applicants' disclosure certainly contemplates that their hydrogen storage material be located in proximity to the hydrogen storage application for efficient and useful delivery of the hydrogen.

It is requested that this rejection be reconsidered and withdrawn.

The Claim Rejections under 35 U.S.C. 103(a)

Claims 1, 3-5, 7, 8, 10-12, 14, 19-21, 26-29, 54, 55, 57, 63, 67-70 are rejected under 35 U.S.C. 103(a) as being unpatentable over Machin et al. (“Kinetics of the Reaction of Water Vapour with Crystalline Lithium Hydride”) in view of Long (US 5702491).

Claims 15, 48, 49, 61, 64-66 are rejected under 35 U.S.C. 103(a) as being unpatentable over Machin et al. (“Kinetics of the Reaction of Water Vapour with Crystalline Lithium Hydride”) in view of Long (US-5702491) in further view of Amendola et al. (US 2004/0033194).

It is requested that each of these rejections be reconsidered and withdrawn for the following reasons.

While some aspects of applicants’ claimed invention have been discussed in response to the Examiner’s rejections under Section 112 of 35 U.S.C., applicants seek to more fully summarize their claimed methods for producing hydrogen as follows.

The Claimed Invention

Independent claims 1 and 67 are method claims which require the preparation of a mixture of particles of a hydride and a hydroxide for release of hydrogen upon demand. As recited in several dependent claims, the hydroxide may include hydrated hydroxide. The prepared mixture is placed in a hydrogen storage device adapted for the release of hydrogen from the prepared and stored mixture, and for delivery of hydrogen to the hydrogen consuming application. Subsequent references in the claims to “the mixture” are references to “the prepared mixture”, placed in the hydrogen storage device.

Upon a demand for hydrogen from the stored mixture, water is reacted with a portion of the hydride particles, now in the mixture in the hydrogen storage device, to produce heat to initiate reaction between a second portion of hydride particles which are mixed with and in contact with particles of the hydroxide. The proportions of hydride particles and hydroxide particles in the prepared and stored mixture (of each of claims 1 and 67) are such that the total content of hydride particles reacts substantially completely with the water and hydroxide particles to form hydrogen for the hydrogen consuming application. The hydrogen leaves the

storage device for use in the hydrogen consuming device. As the prepared and stored mixture is thus consumed, substantially the only residue of the hydride and hydroxide particles is a solid oxide or mixture of oxides. At the completion of the demand for hydrogen and its delivery from the hydrogen storage device, the oxide content remains as substantially the sole residual material in the hydrogen storage device.

Thus, the composition of the prepared and stored mixture is such that the hydride particles and hydroxide particles are substantially fully consumed in their release of hydrogen so that only an oxide of their cations remains. In accordance with the claimed method, a mixture of hydride particles and hydroxide particles are prepared in proportions that effectively produce hydrogen on demand and leave a residue of only an oxide of the starting materials. In accordance with a companion application to this application (now patented), the oxide may be processed back to one or both of the hydride or hydroxide starting materials. Further, in accordance with the claimed methods, when hydrogen is needed, a quantity of water is reacted with a portion of the hydride particles in the prepared and stored mixture to initiate further hydrogen-producing reaction between hydride particles and hydroxide particles.

Certainly, no combination of the disclosures of the Machin et al publication, the Long patent and the Amendola published application suggests or makes obvious any of the method claims of this application.

The rejections of claims 1, 3-5, 7, 8, 10-12, 14, 19-21, 26-29, 54, 55, 57, 63, 67-70 as being unpatentable over Machin in view of Long.

The basis of these rejections is stated by the Examiner as follows. The Examiner observes that Machin discloses a reaction between solid lithium hydroxide hydrate and solid lithium hydride to produce hydrogen and lithium hydroxide. The Examiner then cites the Long patent as showing the delivery of hydrogen from hydrolyzation of lithium hydride to a fuel cell.

The Examiner acknowledges that neither Machin nor Long teaches preparing any mixture of hydride particles and hydroxide particles and using the mixture in a hydrogen storage device to produce hydrogen and deliver it to a hydrogen using application. And, certainly, no combination of the Machin and Long disclosures suggest the preparation of an initial mixture of hydride particles and hydroxide particles fully reactable to form hydrogen and a residue of one or more oxides. But the Examiner argues that Machin places lithium hydride in a reactor and adds

water to form hydrogen and lithium hydroxide particles. The Examiner says that Machin eventually forms a mixture of lithium hydride and lithium hydroxide by consuming some lithium hydride in its reaction with water. The Examiner argues that Machin's order of preparation of a mixture of hydride and hydroxide makes no difference in justification of the above rejection of applicants' claims. The Examiner cites the MPEP 2144.04 (IV)(C) as supporting a prima facie case of obviousness. But the Ex Parte Rubin cases and their fact situations are not applicable with respect to applicants' claims and the Machin disclosure. One cannot simply reverse some aspect of Machin's adding water to preheated lithium hydride to arrive at applicants' claimed methods. In the Machin process, the relative amounts of lithium hydride and lithium hydroxide would be difficult to control. One cannot know whether the hydride is reacting with water or hydroxide or some other reaction product. And the locations of the Machin hydride and the forming hydroxide for some subsequent inter-reaction would be impossible to control. Contrary to the Examiner's speculation, one cannot simply change orders of preparation in the Machin process to suggest or teach applicants' methods.

In applicants' claimed methods, the necessary amounts of hydride and hydroxide components of the particulate mixture are fully ready for reaction as prepared and placed in a storage device. The addition of water or the use of hydrated hydroxide is then used to start hydrogen production in the already prepared and stored mixture of particles. When the hydrogen production reaction is started one does not then have to alter the prepared and stored mixture. In accordance with applicants' claimed methods, one does not then decide to alter components in a previously loaded storage device. And there is no advantage to altering previously added components to form new components in the storage device. In applicants' claimed methods, hydrogen can be released by the addition of a small amount of water to quickly heat and initiate a reaction between two components already in the particulate mixture. Nothing more needs to be added. The fully reactable components are already present and mixed in applicants' methods. Applicants have clearly and repeatedly demonstrated that their method of preparing a mixture of particles of a hydride and a hydroxide maximizes the use of a volume or weight of such a mixture in the production of hydrogen, and in the formation of an oxide that can be regenerated for use in a hydrogen storage mixture. Applicants' claimed methods are not some change in sequence of addition of reactants in a Machin kinetic study practice.

In the Machin disclosure only the hydride is initially present. Depending on the temperature of his hydride and how he adds water, Machin can obtain a variety of hydroxides, oxides and hydrated species of hydrides, hydroxides and oxides. There is no set sequence of addition in Machin that resembles applicants' methods. A user of the Machin process doesn't know how much hydride is converted, or whether portions of any remaining hydride and any formed hydroxide are suitable for best use of the original hydride charge. Except for using all of Machin's hydride to form hydroxide there is no good way to proceed with hydrogen production without leaving unused hydroxide. The Machin falls far short of applicants' efficient methods.

Machin provides no clue to applicants' hydrogen storage materials and hydrogen release strategy, and neither does the Long patent.

The inventors in the Long patent must be presumed to have been aware of the Machin disclosure. So it is revealing that Long, like Machin, starts with a hydride material, reacts the hydride with water to form hydrogen and a hydroxide, which still contains hydrogen. But after Long and Machin have reacted all their hydride starting material with water, they still have an abundance of hydroxide material which could have been beneficially used in a suitable mixture prepared and placed in a hydrogen storage device. Machin and Long may be a combination of like practices, but they certainly don't teach applicants' claimed methods.

Neither Machin nor Long teaches or suggests preparing a mixture of a hydride and hydroxide particles for release of hydrogen on demand.

Neither Machin nor Long teaches or suggests preparing a mixture of hydride and hydroxide particles for release of hydrogen on demand and placing the mixture in a hydrogen storage device adapted for release of hydrogen from the device and delivery of the hydrogen to a hydrogen consuming application.

Neither Machin nor Long teaches or suggests a method of reacting a first portion of the hydride particles in the prepared mixture with water to produce heat in an amount to initiate reaction between a second portion of hydride particles with particles of hydroxide to produce hydrogen by such hydride-hydroxide reaction for a hydrogen consuming application.

Neither Machin nor Long teaches or suggests the preparation and storage of a mixture of hydride and hydroxide particles in proportions so that the total amount of hydride particles reacts substantially completely with the water and the particles of hydroxide to form hydrogen and a residue that is substantially only an oxide.

Accordingly, it is requested that the rejections of applicants' claims 1, 3-5, 7, 8, 10-12, 14, 19-21, 26-29, 54, 55, 57, 63, 67-70 be reconsidered and withdrawn.

The rejections of claims 15, 48, 49, 61, 64-66 as being unpatentable over Machin in view of Long in further view of Amendola.

Applicants' claims 15, 48, 49, 61, and 64-66 are dependent claims in which the hydride particles comprise lithium borohydride. These dependent claims are rejected on a combination of Machin with the Long patent and the Amendola et al published application.

The combination of the Machin publication and the Long patent fail to teach or suggest applicants' independent claims 1 and 67 for the reasons presented above in this paper. The Amendola application discloses practices for the use of aqueous borohydride solutions with stabilizers and catalysts to produce hydrogen. But the methods of the Amendola disclosure are unrelated to any of the Machin disclosure, the Long disclosure, and to applicants' claimed methods. Each of the above differences between applicants' independent claims and any combination of Machin and Long is applicable in distinguishing combinations of the Machin, Long, and Amendola disclosures from applicants' claimed methods. The rejections of claims 15, 48, 49, 61, and 64-66 should also be reconsidered and withdrawn.

The methods recited in applicants remaining claims are supported by their specification and are patentable over the combinations of the disclosures of Machin, Long, and Amendola. It is requested that each of claims 1, 3-5, 7, 8, 10-12, 14, 15, 19-21, 26-29, 48, 49, 54, 55, 57, 61, and 63-70 be allowed and this case passed to issue.

Respectfully Submitted,

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